Towards Atmospheric Compensation of Low Altitude High Spatial Resolution UAV Based Imagery

Daniel Schläpfer, Christoph Popp

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Rudolf Richter

DLR Wessling

Panels in the field ...

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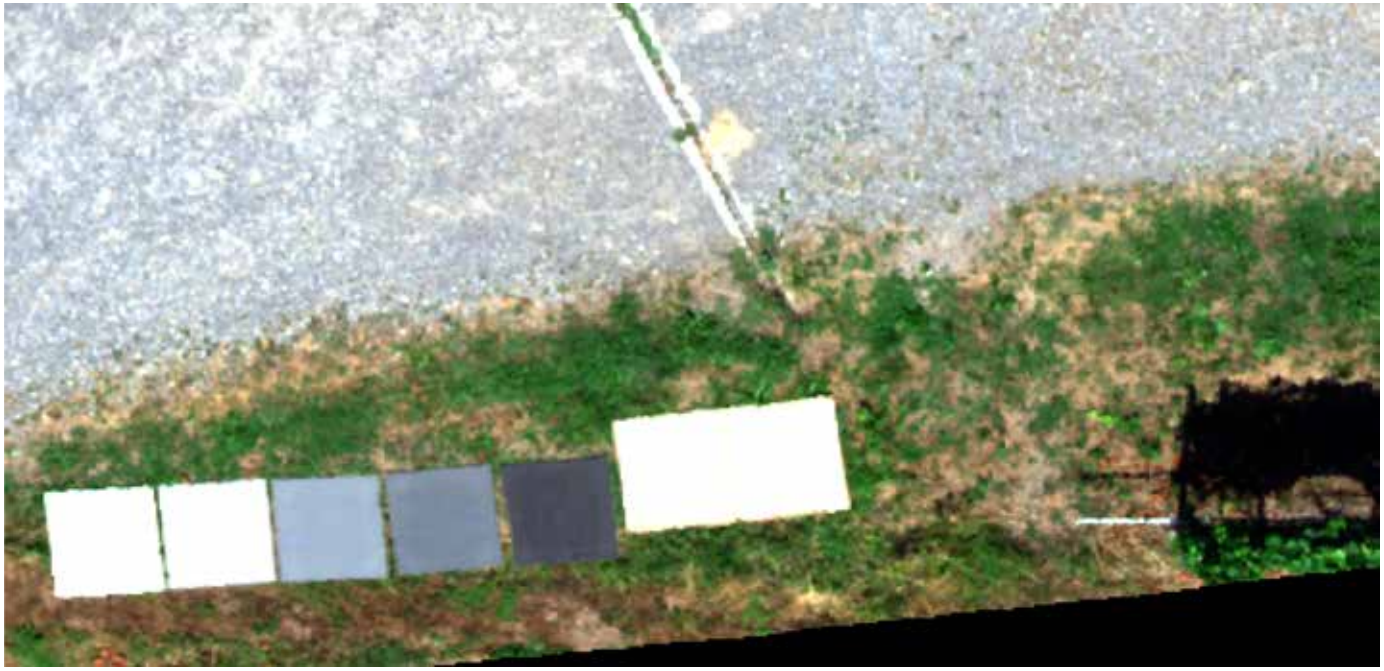

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Goals

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Questions:

How to make best use of these panels?

Do you need atmospheric compensation for close range remote sensing?

.. let's evaluate normalization strategies based on reference panels and recommend possible improvements (if needed)

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Contents

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1. Problem description and data basis
2. Some radiative transfer simulation within the first 200 m above ground
3. Validation of empirical line correction on Hyperspec Nano data
4. Impact on Vegetation analysis
5. Potential of atmospheric compensation methods
6. Conclusions and Outlook

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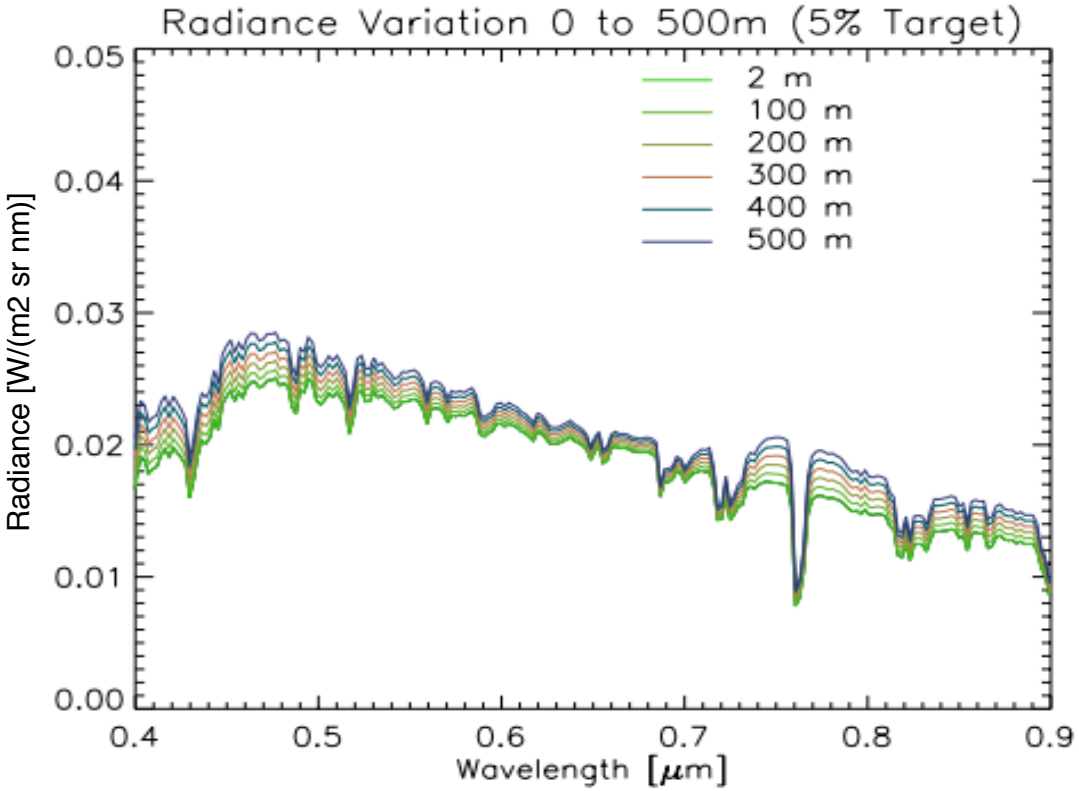
Radiance Variations over Dark Object



MODTRAN-Simulation

Water vapour: 2g/cm2
Visibility: 23km
Solar Zenith: 24 def
Adjacency: Soil reflectance

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Radiance Variations over Bright Object

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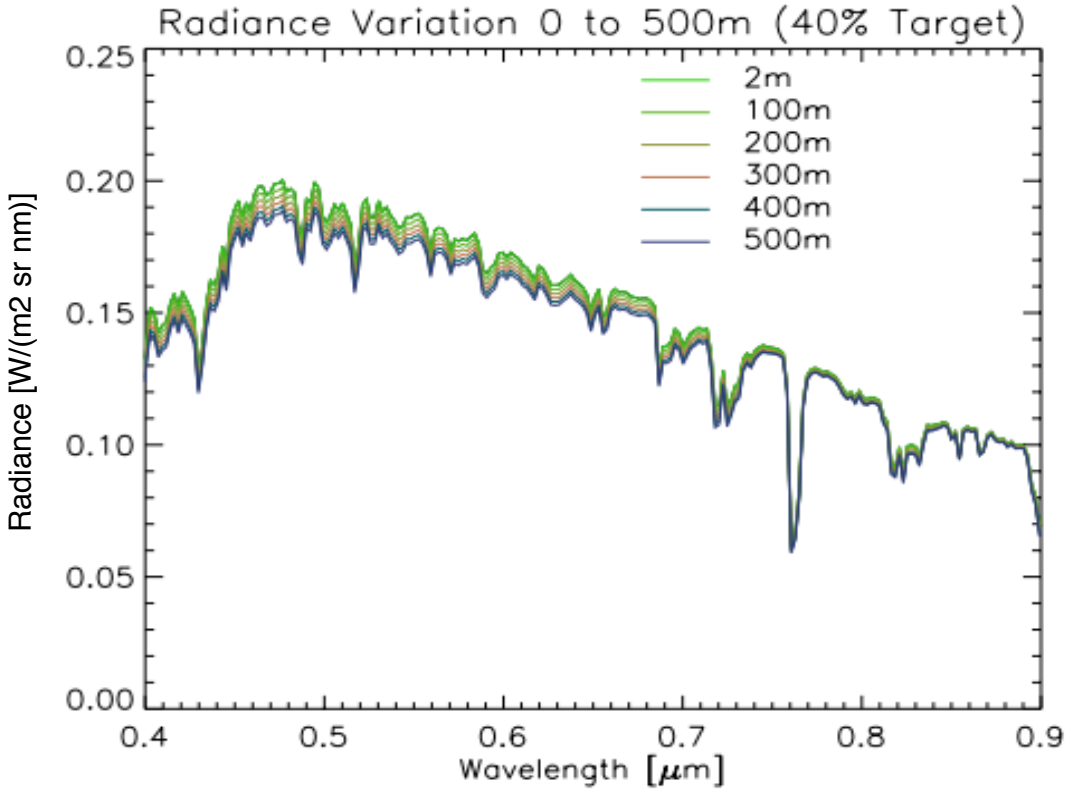

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Variation over Vegetation

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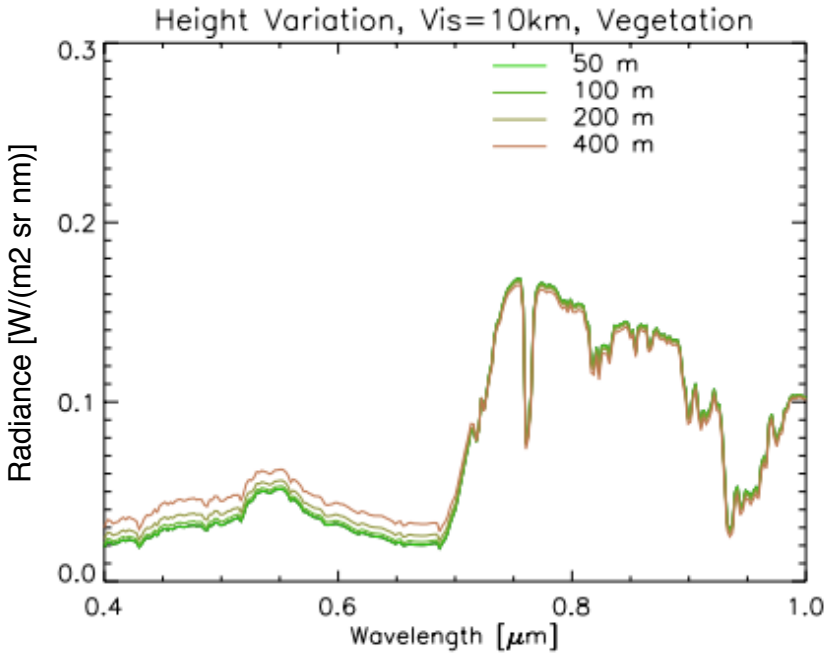

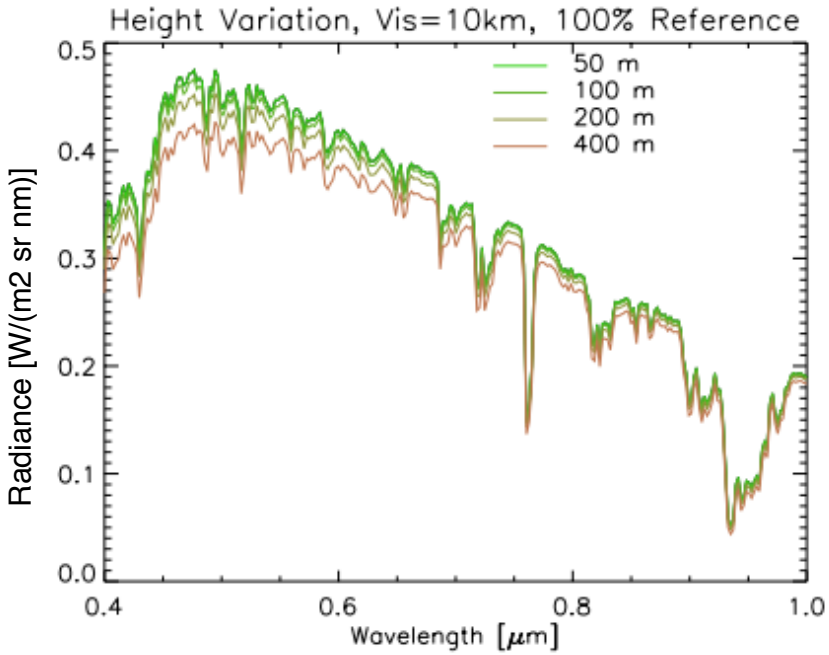

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Retrieved Reflectances Accuracy (with white Reference Panel)

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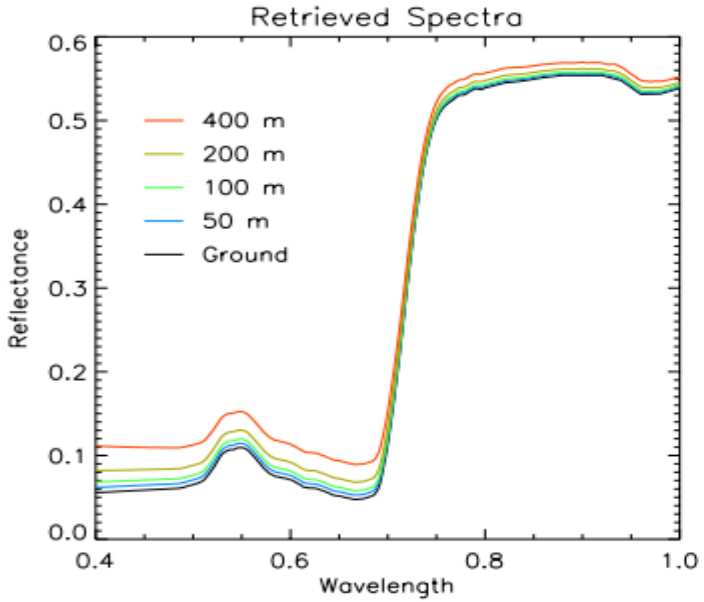

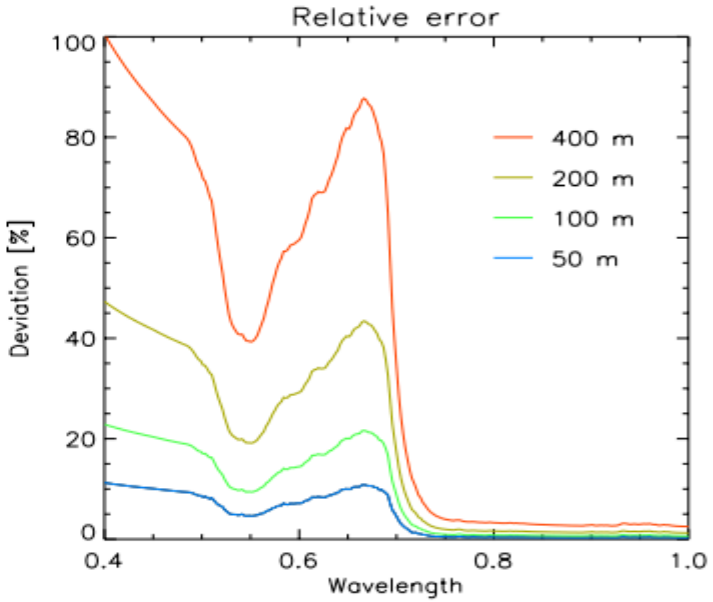

	Ground	50m	100m	200m	400m
NDVI	0.767	0.753	0.739	0.713	0.661
PRI	0.085	0.081	0.077	0.071	0.062

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Experimental Setup

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Imaging Spectroscopy Data:

- Headwall Hyperspec Nano III
- no radiance calibration available
- mounted to DJI Matrice 600 UAV with
- GPS/IMU: Xsens MTi
- Geometric processing with PARGE
- Flight altitudes: **30 m, 100 m, 200 m (a.g.)**
- Acquistion: Rapperswil, Switzerland, June 2018.

The data has been provided by Agricircle AG, Rapperswil, Switzerland
Thanks to Peter Fröhlich, peter@agricircle.com

agri circle

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Panel Reflectances

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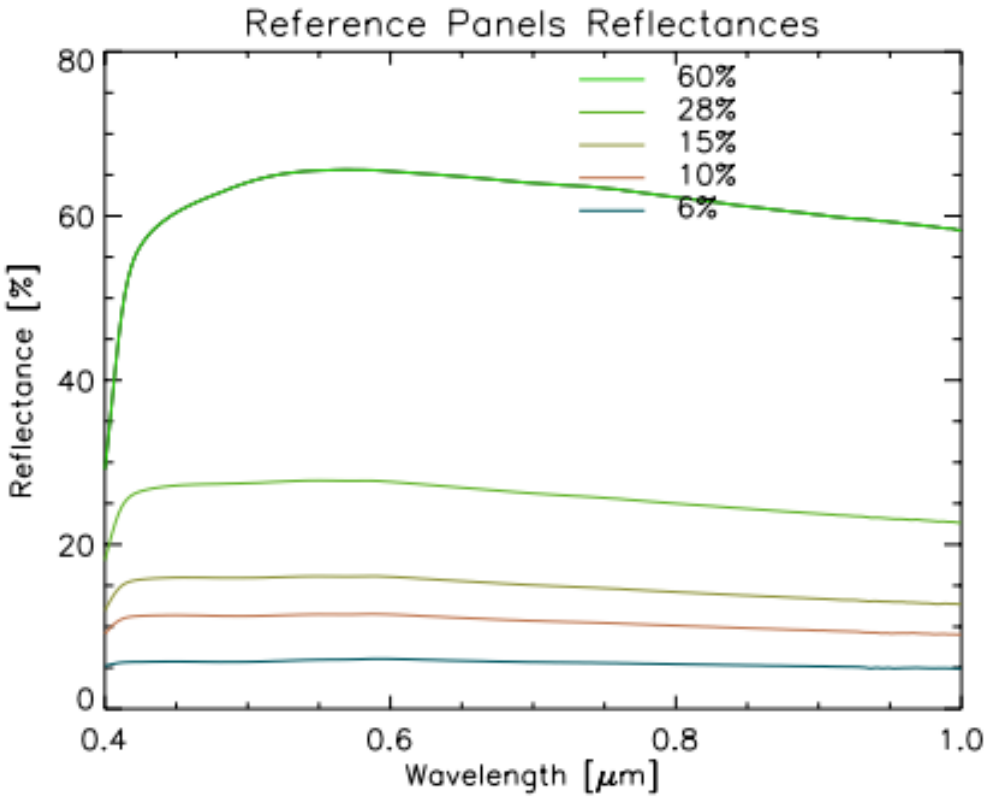
0,25,50,100 % ?



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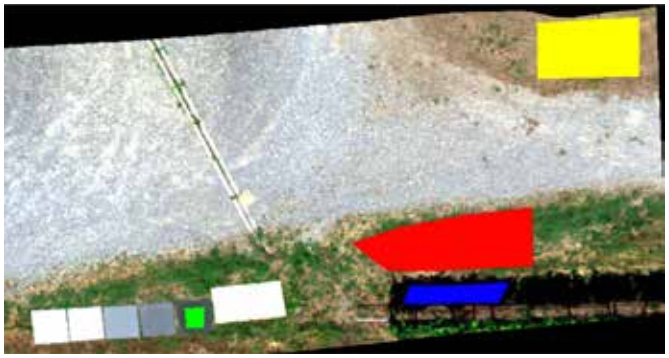
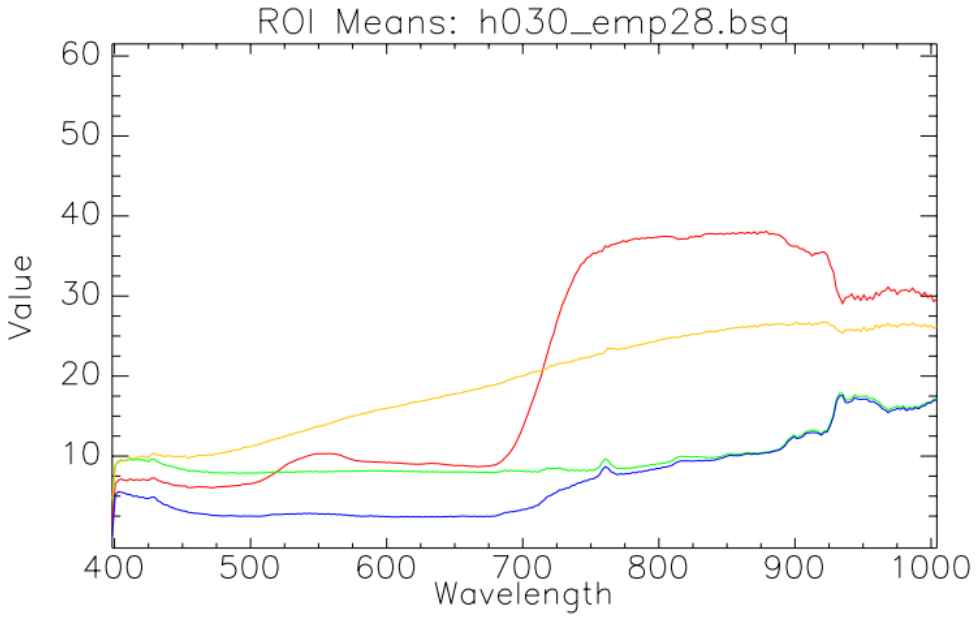
Bright Target Correction



True Color / ROI Locations

Using a single reflectance target



Grass
Soil
6% Target
Shadow

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Remember the Empirical Line

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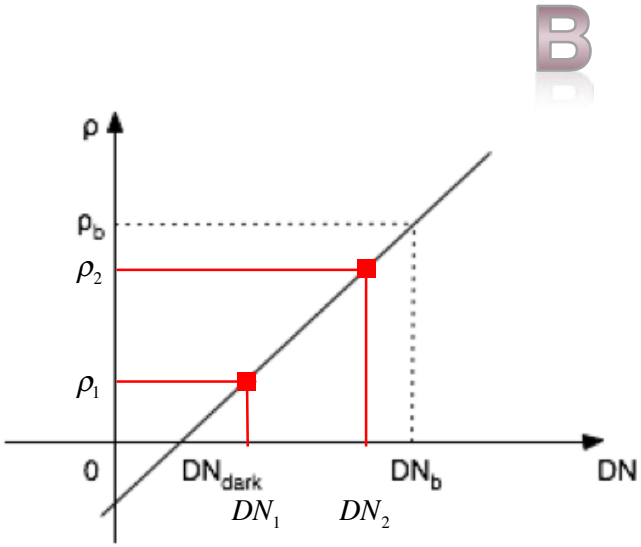
Combination of various known targets into a linear relation:

$$\rho = (DN_s - DN_{dark})\frac{\Delta\rho}{\Delta DN} = (DN_s - DN_{dark})\frac{\rho_2 - \rho_1}{DN_2 - DN_1}$$

Options:

- Combination of bright/dark target
- Using at least 2 known reference targets
- Combining multiple targets by linear fit



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Empirical Line Correction

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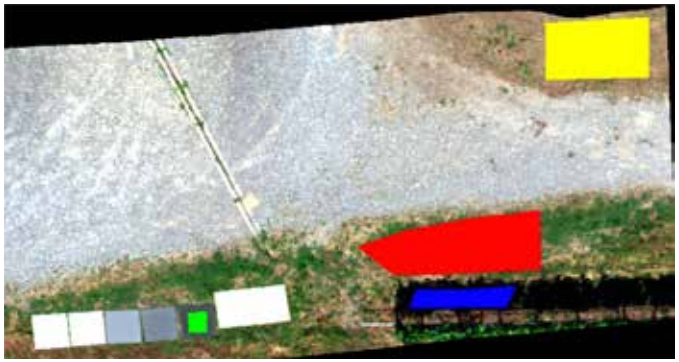
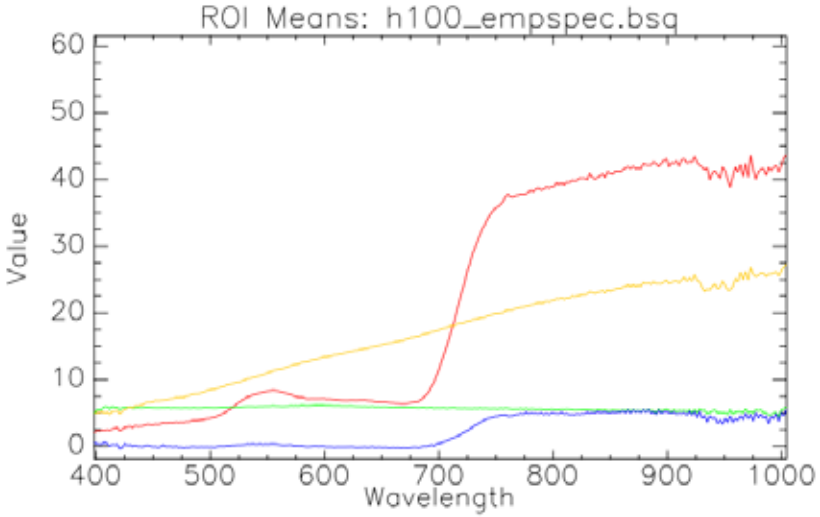


Image Subset, true color with regions of interest

Grass
Soil
6% Target
Shadow

Using a 40% and 10% reflectance target



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Consistency of Indices

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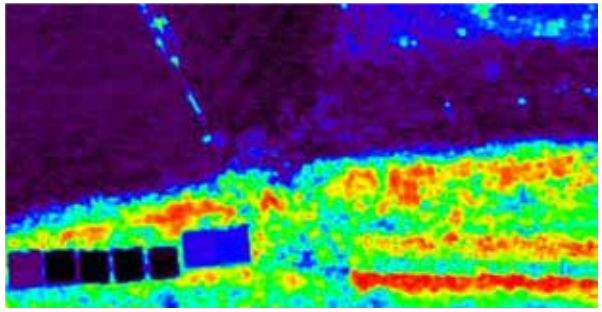
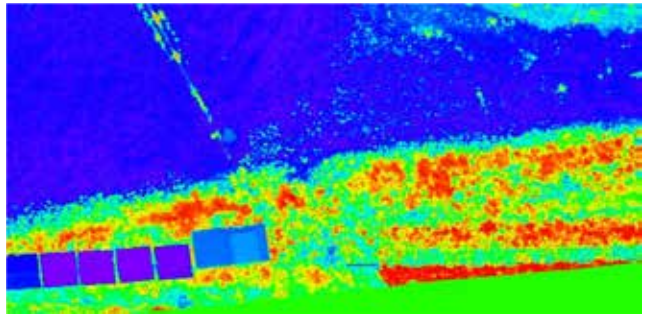
NDVI (same scaling)

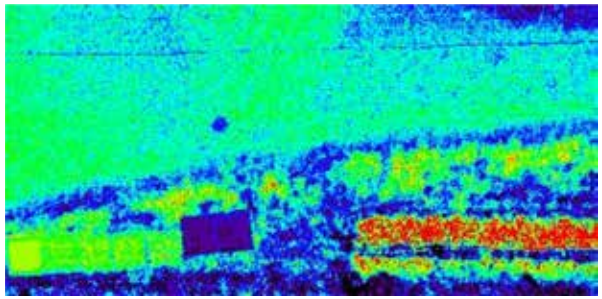


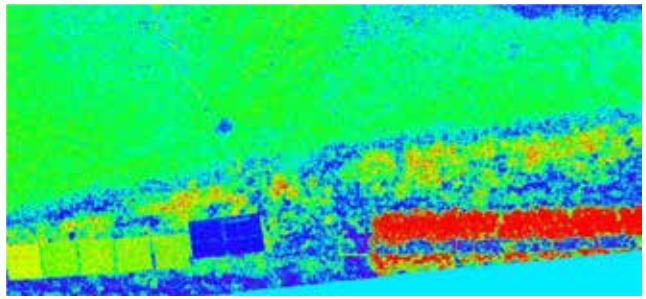


30m a.g.

100m a.g.

PRI (same scaling)





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Vegetation Density?

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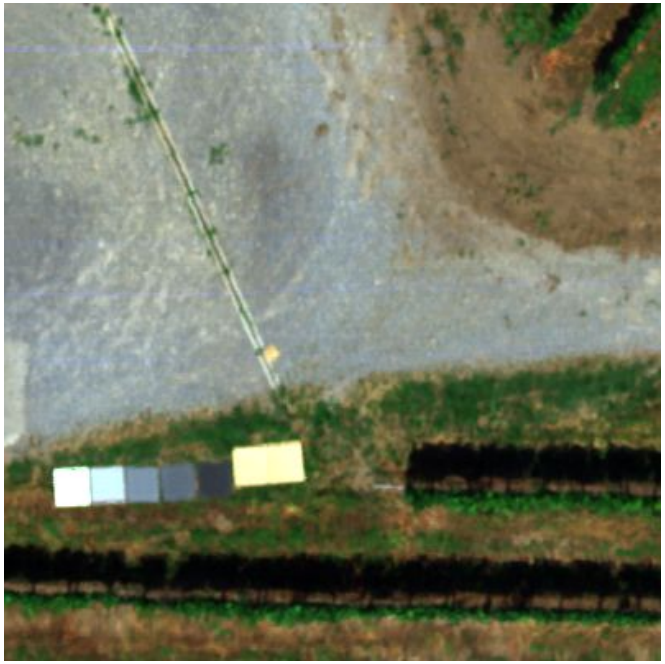
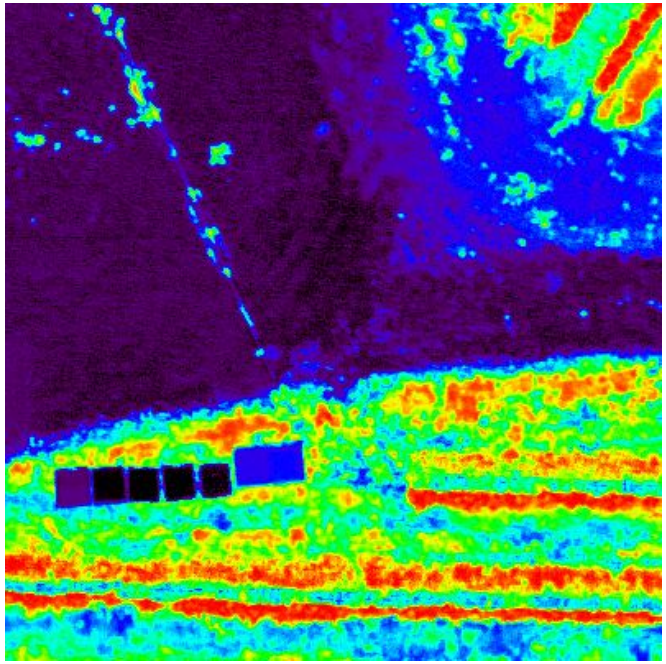
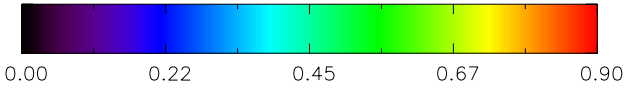


NDVI





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PRI Index in Shadows?

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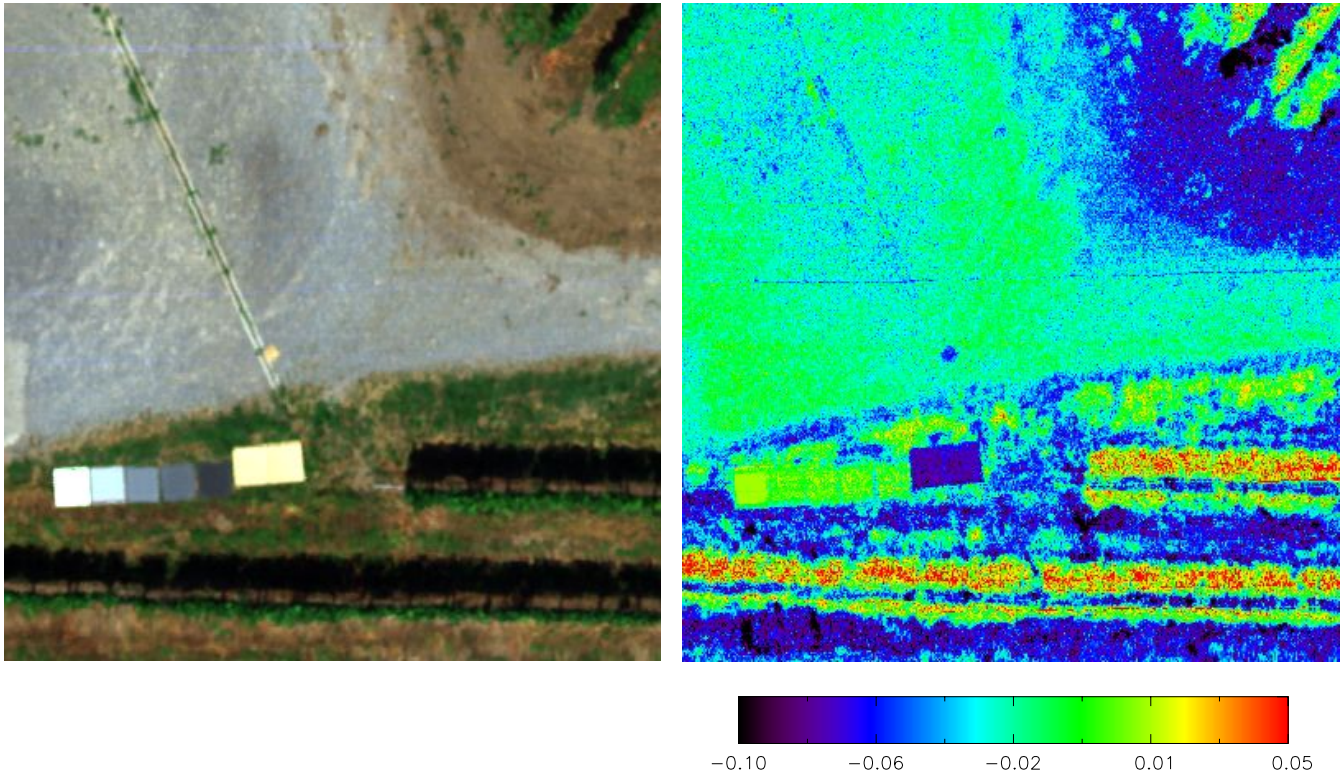
PRI



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Problem: Irradiance in Cast Shadow Areas

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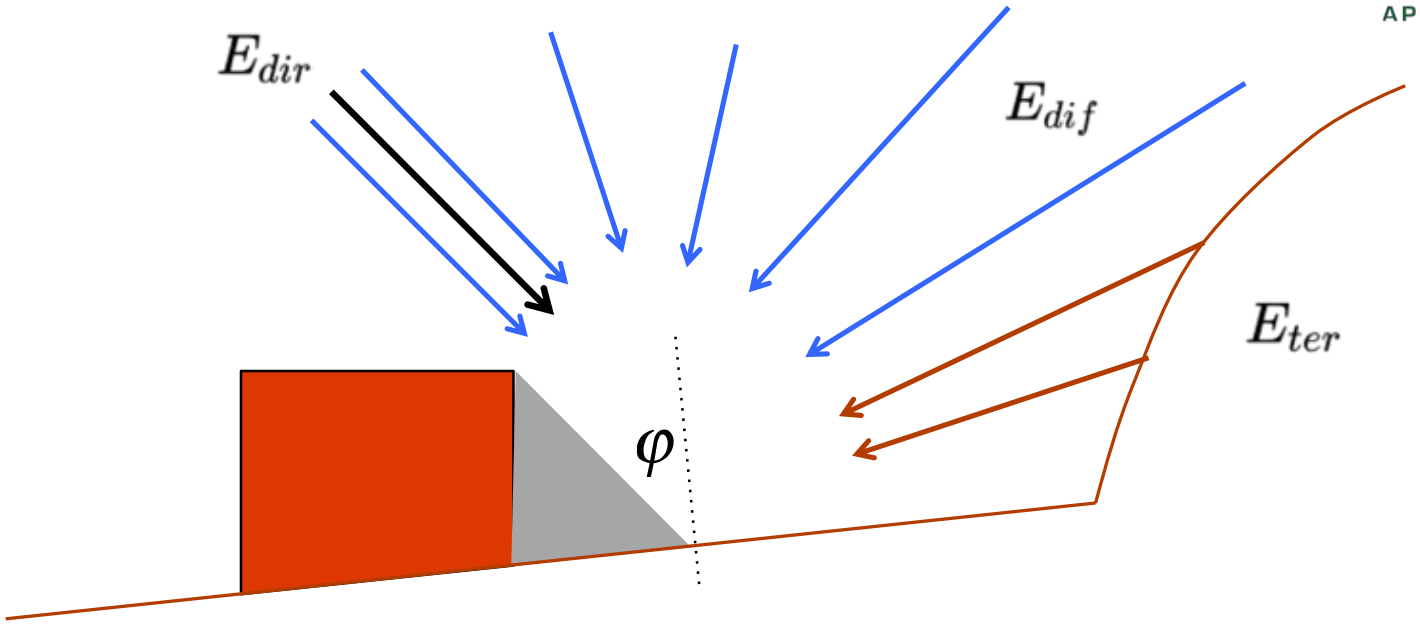

Irradiance in full shade: $E_{shade} = E_{dif} + E_{ter}$

$$= E_{dif,t}(1-\tau_s)\,V_{sky} + \overline{\rho_{ter}}\,\tau_v\,(E_{dir,t}\cos\theta_o + E_{dif,t})\,(1-V_{sky})$$

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Problem 2:
Radiance from Cast Shadow Areas

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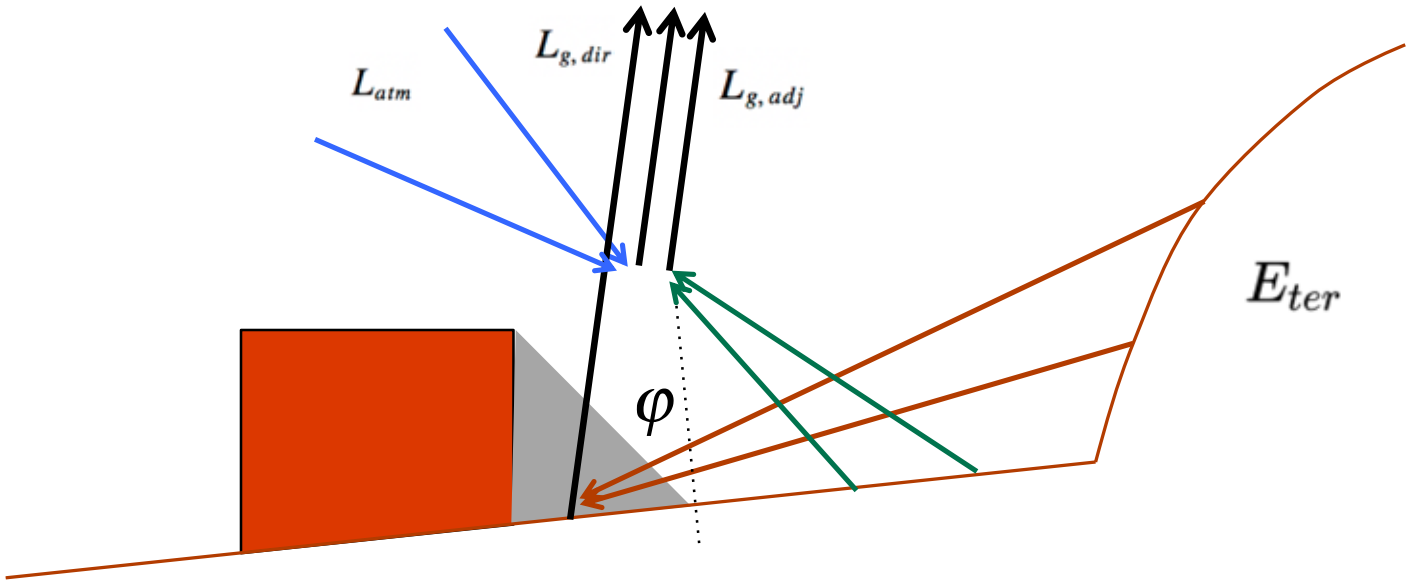

Radiance in shade:

$$L_s = L_{g,\,dir} + L_{g,\,adj} + L_{atm}$$

$$\frac{1}{\pi}E_{dif} \cdot \rho \cdot \tau_u \qquad \frac{1}{\pi}E_g \rho_{adj} \tau_{u,\,adj} \qquad \frac{1}{\pi}E_0 \rho_{atm}$$

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How to deal with Shadows?

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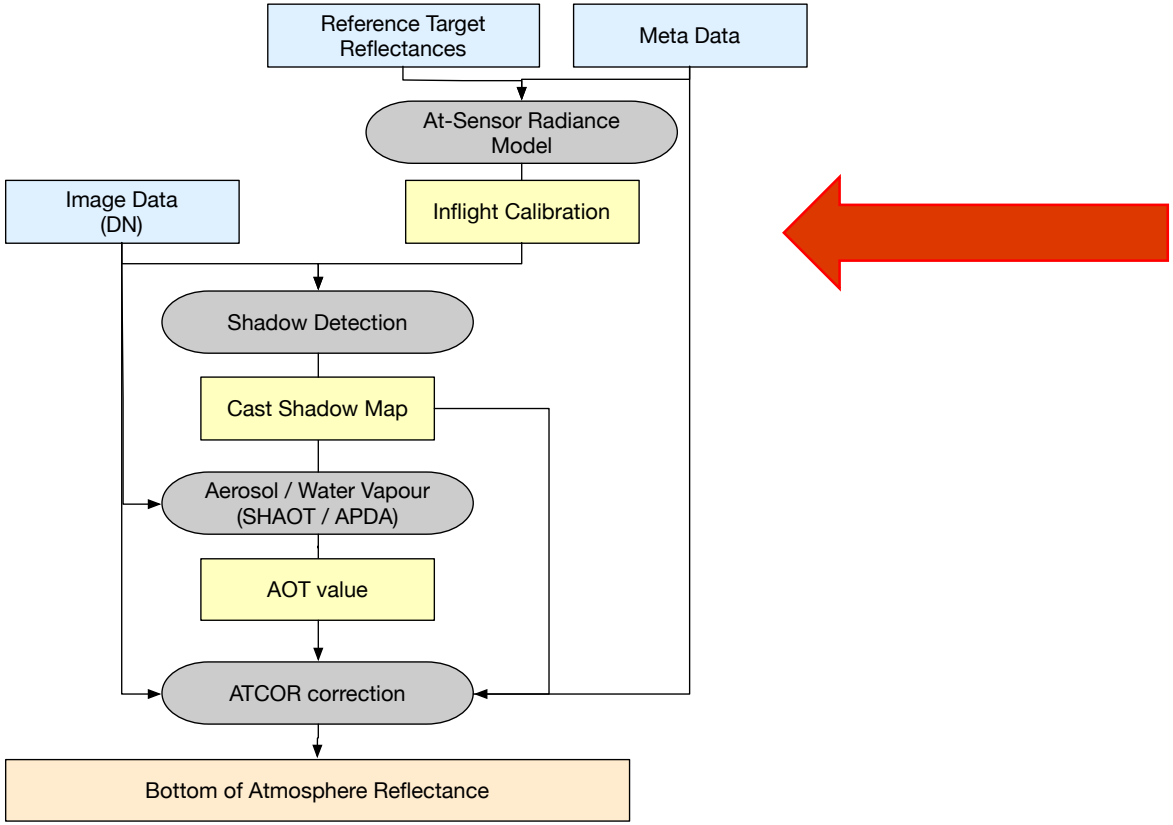

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Atmospheric Compensation Outputs

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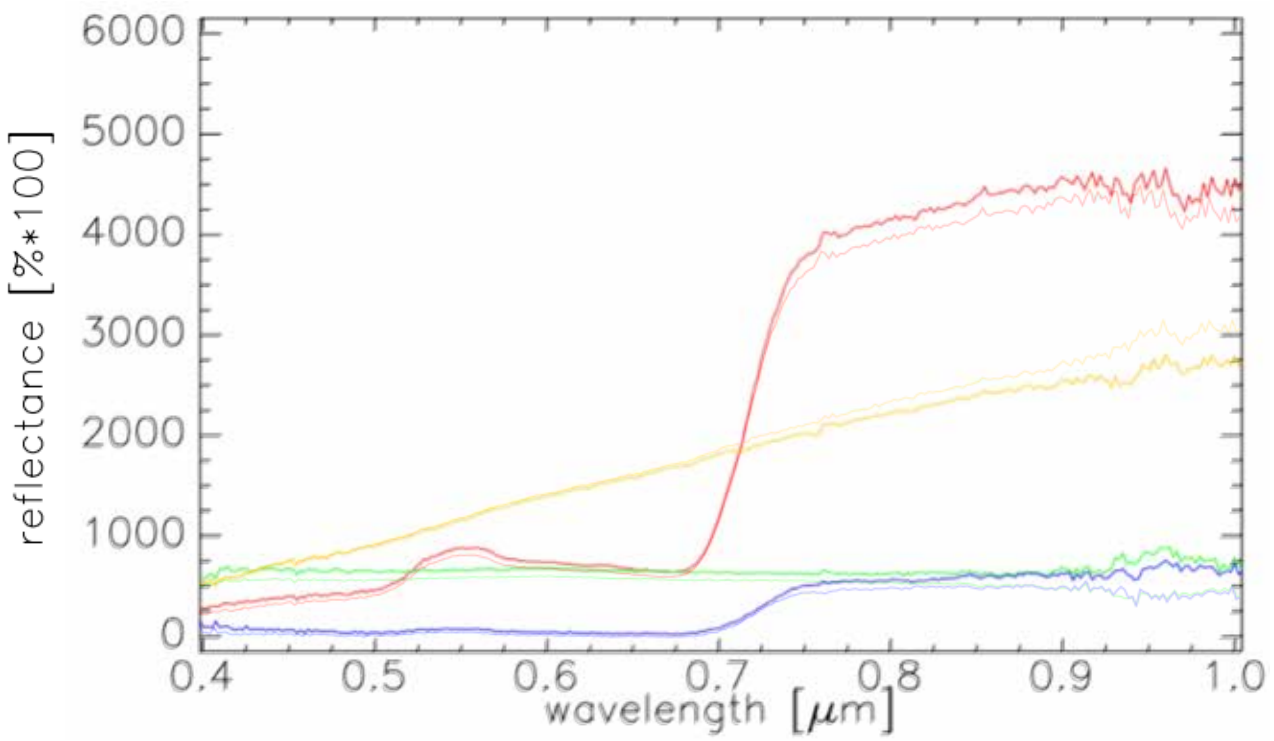
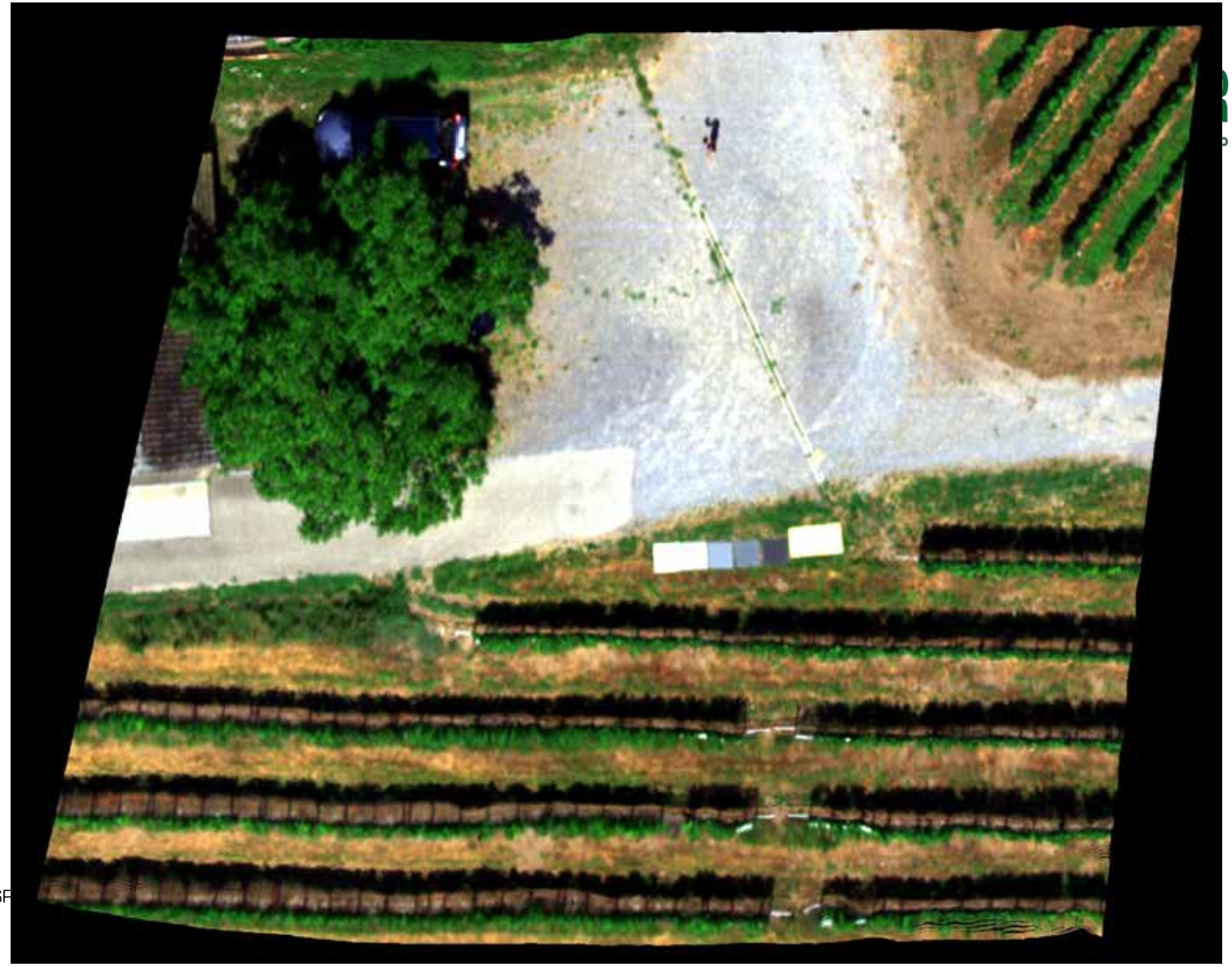
- dual-reference ATCOR-based inflight calibration (on 30m data)
- ATCOR-4 flat terrain correction

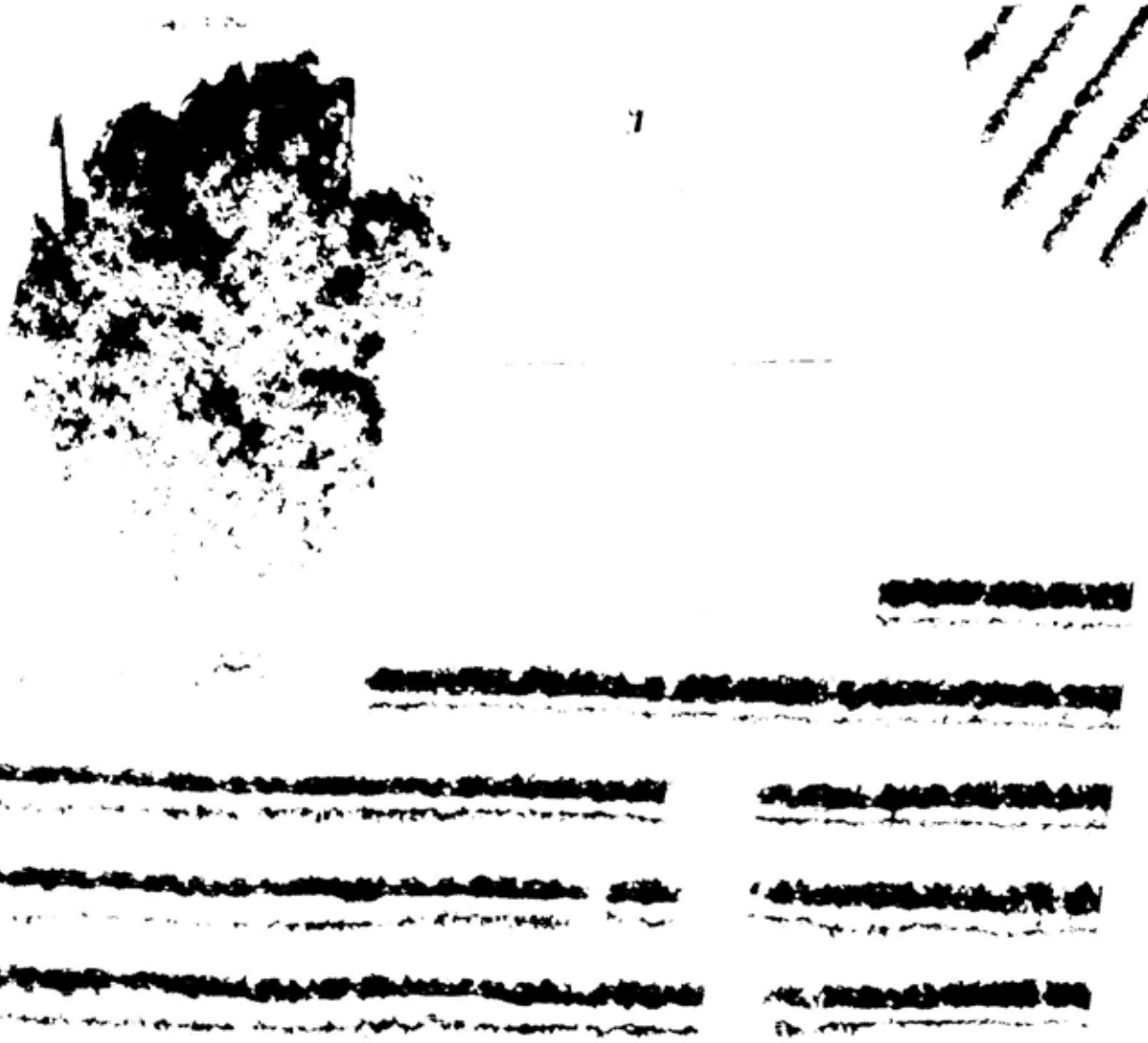
30m



100m

Grass
Soil
10% Target
Shadow





Shadow Correction?

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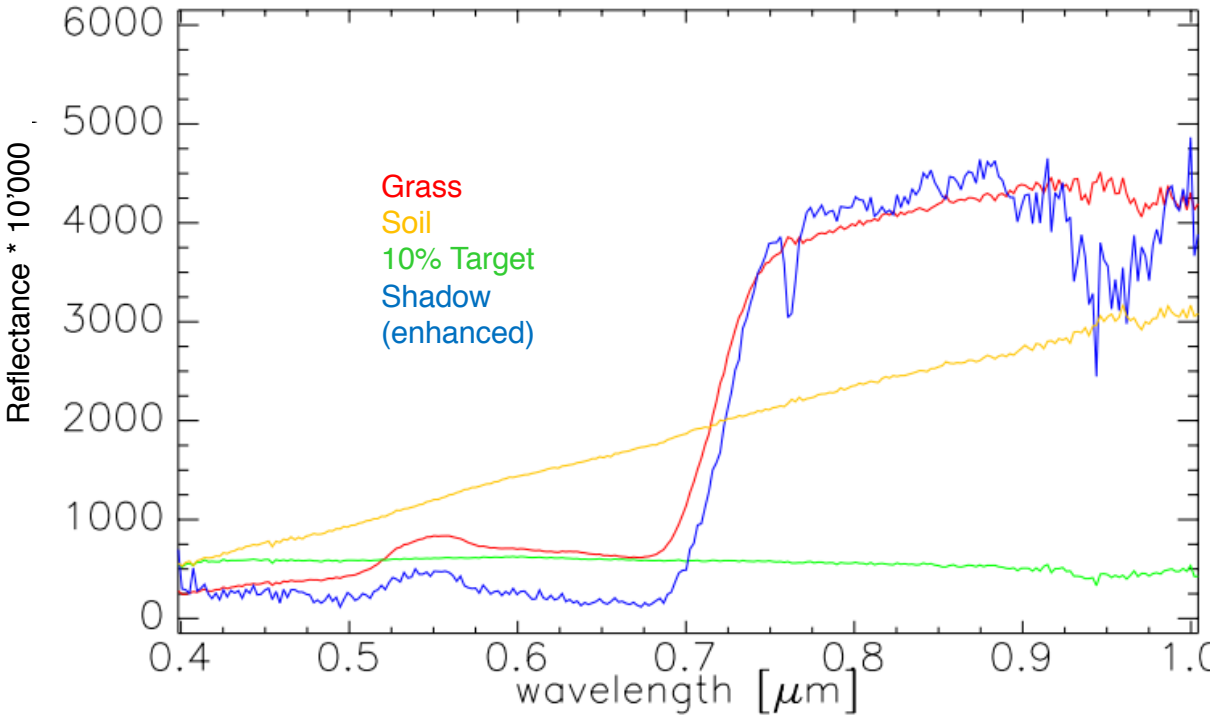

D. Schläpfer, A. Hueni, and R. Richter, "Cast Shadow Detection to Quantify the Aerosol Optical Thickness for Atmospheric Correction of High Spatial Resolution Optical Imagery," *Remote Sensing*, vol. 10, no. 2, p. 25, Feb. 2018.

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Conclusions

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- Single target based reflectance retrieval is affected by various problems, even at 30m above ground.
- Empirical line correction based on illuminated reference targets leads to stable results.
- Correction of shaded areas is not feasible by the empirical approach.
- Vegetation analysis may be biased by false results in shaded areas.
- Physical correction with ATCOR leads to very similar results for directly illuminated targets, but may bear advantages.

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Answers to Initial Questions

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How to make best use of these panels?

- apply empirical line correction, or
- use them for inflight calibration
- don’t do single panel correction

Do you need atmospheric compensation for close range remote sensing?

not really, but

- no need for panels if system is once calibrated
- potential of shadow signature analysis

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Outlook

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- physical reflectance retrieval in shaded areas to be improved
- a streamlined processing workflow is envisaged for semi-empirical correction of UAV based imagery
- such a workflow is applicable to a wide range of hyperspectral and multispectral UAV based imagery

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Empirical vs Atmospheric

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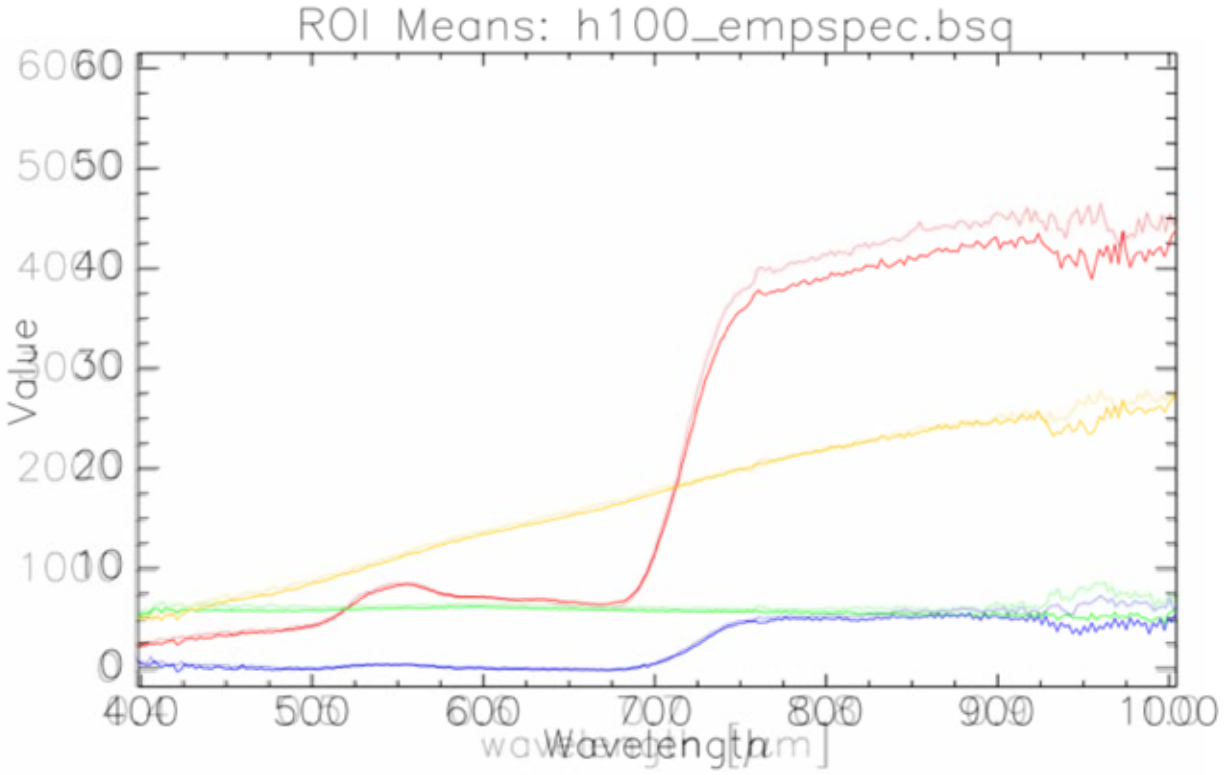

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